

PATENT ABSTRACTS OF JAPAN

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(71)Applicant : SONY CORP

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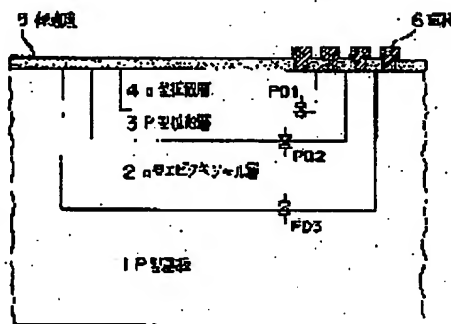
(72)Inventor : KOUZU TAKEMOTO

(54) PHOTODETECTOR

(57)Abstract:

PURPOSE: To enhance a photodetective element in wavelength selectivity and to make a detected output and a spectral luminous efficiency coincident with each other by a method wherein a photoelectric conversion section composed of PN junctions different from each other in wavelength selectivity to light ray incident on a photodetecting plane is provided.

CONSTITUTION: An N-type epitaxial layer 2 is formed on the upside of a P-type substrate 1, and a P-type diffusion layer 3 and an N-type diffusion layer 4 are successively formed on the upside of the N-type epitaxial layer 2. Then, a first photodiode PD1 is formed at a junction surface between the P-type diffusion layer 3 and the N-type diffusion layer 4, a second photodiode PD2 is formed at a junction surface between the P-type diffusion layer 3 and the N-type epitaxial layer 2, and a third photodiode PD3 is formed at a junction surface between the N-type epitaxial layer 2 and the P-type substrate 1. The photovoltaic currents of the photodiodes PD1 to PD3 are determined depending on the depth of a junction surface and the wavelengths of incident ray, so that a detection output coincident with a human sense of sight can be obtained by carrying out a numerical computation for a current value.



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CLAIMS

[Claim(s)]

[Claim 1] The photo detector characterized by having the photo-electric-conversion section which consists of two or more pn junction from which the wavelength selection nature to the light which it is formed in single semi-conductor bulk, and carries out incidence to the light-receiving front face of this semi-conductor bulk differs mutually, and the electrode connected to each semi-conductor layer which constitutes said pn junction.

[Claim 2] The photo detector according to claim 1 in which said each semi-conductor layer is formed in the shape of a laminating.

[Claim 3] The photo detector according to claim 1 or 2 from which the band gap of each of said pn junction differs mutually.

[Claim 4] A photo detector given in any 1 term of the claims 1-3 further equipped with the arithmetic circuit which has the input connected to said each electrode.

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DETAILED DESCRIPTION**[Detailed Description of the Invention]****[0001]**

[Industrial Application] Especially this invention relates to the photo detector of photodiode structure about a photo detector.

[0002]

[Description of the Prior Art] A brightness detector is used for detection of the existence of light, measurement of luminous intensity and power, etc. Especially, in the brightness detector used for luminous-intensity measurement using photodetectors, such as CdS and Si, since the wavelength selection nature is uniquely decided by the property concerned of CdS, or structure of Si photodetector, it cannot select wavelength selection nature to incident light freely.

[0003]

[Problem(s) to be Solved by the Invention] In the conventional photodetector, wavelength selection nature to incident light cannot be selected freely, and the wavelength selection nature is not in agreement with a visibility curve and a sufficient precision. For this reason, it was difficult to obtain the brightness detector a gap is between the output of brightness detection of a photodetector, and human being's feeling, and it can be efficiently satisfied with it of a detector.

[0004] Since this invention is easy to select wavelength selection nature in view of the problem of the above-mentioned conventional brightness detector, it aims at making the detection output in agreement with relative luminous efficiency offering and having an easy photo detector, and precision obtaining a high brightness detector.

[0005]

[Means for Solving the Problem] In order to attain said purpose, the photo detector of this invention is formed in single semi-conductor bulk, and is characterized by having the photo-electric-conversion section which consists of two or more pn junction from which the wavelength selection nature to the light which carries out incidence to the light-receiving front face of this semi-conductor bulk differs mutually, and the electrode connected to each semi-conductor layer which constitutes said pn junction.

[0006] As for wavelength selection nature, it is desirable to arrange and obtain the semi-conductor layer which constitutes each junction to a laminated structure, or it is obtained also as what is different in the band gap in each junction.

[0007] It is also the desirable mode of this invention that a photo detector is equipped with the arithmetic circuit which has the input connected to each electrode which takes out the signal current from the photo-electric-conversion section. In this case, in order to make the output of a photo detector agree with a sufficient precision in relative luminous efficiency, in this arithmetic circuit, it is desirable to combine this, adding math processing to the signal current taken out from each electrode.

[0008]

[Function] Since the signal current taken out from each electrode is combinable suitably with the configuration which a photo detector equips with two or more pn junction which has wavelength selection nature which is mutually different to the light which carries out incidence to a light-receiving front face, and the electrode connected to the semi-conductor layer from which each [these] pn junction is constituted, the photo detector which has desired wavelength selection nature is obtained, and it can consider as the photodetector which has the wavelength selection nature which is in agreement with a relative spectral sensitivity curve with a sufficient precision.

[0009] When adopting the configuration which arranges the semi-conductor layer which constitutes each junction to a laminated structure, it is easy to differ the wavelength selection nature of each junction to the incident light on the front face of light-receiving mutually. Moreover, if the configuration which forms the band gap in each junction in a different value between [each] junction is adopted, selectivity over the wavelength of light will be made to a different value in each junction.

[0010] If the configuration which prepares the operation part by which an input is connected to the electrode connected to each semi-conductor layer which constitutes pn junction, respectively is

adopted, the photo detector of a simple configuration of that the wavelength selection nature to the incident light on the front face of light-receiving can be selected easily will be obtained by choosing the contents of an operation in this operation part.

[0011]

[Example] With reference to a drawing, this invention is explained in more detail. Drawing 1 is the sectional view showing the structure of the photo detector of one example of this invention. In this drawing, growth formation of the n mold epitaxial layer 2 is carried out on the p mold substrate 1 top face, and p mold diffusion layer 3 and n mold diffusion layer 4 are formed in the top face of this n mold epitaxial layer 2 in the shape of a laminating one by one. Each epitaxial layer and a diffusion layer can be formed in the process for forming a bipolar transistor, respectively.

[0012] The light-receiving front face which consists of principal planes of a substrate including the field which consists of diffusion layers 3 and 4 and an epitaxial layer 2 is covered, and the protective coat 5 of transparency is formed. In the predetermined location of each [these] semi-conductor layers 1-4, a protective coat 5 is removed alternatively, a contact hole is formed, respectively, and an electrode 6 is formed in each of that part, respectively. Each semi-conductor layer which consists of a substrate 1, n mold epitaxial layer 2, and each diffusion layers 3 and 4 is connected to the predetermined arithmetic circuit which is not illustrated through the electrode 6 which corresponds, respectively.

[0013] a photo detector -- from the light-receiving front-face side -- one by one -- the second photodiode PD 2 is formed in the plane of composition of p mold diffusion layer 3 and n mold epitaxial layer 2, and the third photodiode PD 3 is formed in the plane of composition of n mold epitaxial layer 2 and p mold substrate 1 for the first photodiode PD 1 in the plane of composition of n mold diffusion layer 4 and p mold diffusion layer 3, respectively. With these configurations, each photodiode shall have changed in the depth from a light-receiving front face.

[0014] Drawing 2 is a circuit diagram which illustrates the circuit which takes out a current from the photo detector of the above-mentioned example. The photocurrent produced with Photodiode PDn is set to in among drawing, and e_n has shown each electrode by making into a subscript the reference mark (n) given to each corresponding semi-conductor layer. The electrode e_2 connected to the electrode e_4 connected to n mold diffusion layer 4, and n mold epitaxial layer 2 in this drawing It connects with the arithmetic circuit which is not illustrated through the bipolar transistors Q1 and Q2 which the base is maintained by predetermined potential and are in switch-on, respectively. Moreover, the electrode e_3 of p mold diffusion layer 3 The base is similarly connected to an arithmetic circuit through the bipolar transistor Q3 which is maintained by predetermined potential and is in switch-on. The electrode e_1 of p mold substrate field 1 is directly connected to an arithmetic circuit.

[0015] When light carries out incidence to a photo detector by the above-mentioned configuration, as shown in drawing 2, a photocurrent i_1 , i_2+i_3 , and i_1+i_2 are independently taken out from transistors Q1, Q2, and Q3, respectively, and it is inputted into an arithmetic circuit. In an arithmetic circuit, since i_1 and i_1+i_2 to i_2 is obtained and i_3 is obtained from this and i_2+i_3 , i_1 , i_2 , and i_3 are obtained independently after all, respectively. Therefore, math processing of arbitration becomes possible by multiplying the suitable numeric value for these, or adjusting.

[0016] The quantum efficiency generally expressed with the photo detector which consists of a photodiode as a ratio of the number of radiation photoelectrons to the number of incident light children becomes settled with the depth from the light-receiving front face of the plane of composition, and the wavelength of incident light. In this case, incident light with longer wavelength raises the quantum efficiency in a deeper plane of composition. In the photodiode of the bipolar structure shown in drawing 1, the depth from a light-receiving front face differs mutually, and each photodiodes PD1, PD2, and PD3 differ in quantum efficiency according to the wavelength of incident light, respectively.

[0017] Drawing 3 has illustrated the wavelength dependency of the ratio to each current i_1 of each photodetectors PD1, PD2, and PD3; i_2 , and i_3 current of the whole about the case where wavelength receives the incident light from 400nm to 800nm on a light-receiving front face. In incident light with short wavelength, current i_2 and the ratio of i_3 increase as the most is obtained as a current i_1 and wavelength becomes long. The ratio which a current i_3 occupies increases the ratio of current i_2

while the ratio of current i_2 falls as wavelength shows the maximum between 500nm and 600nm and wavelength becomes long rather than it.

[0018] By the way, it is known that the number of photons contained in the light of the same reinforcement is proportional to wavelength, and the photocurrent i_1 acquired from the incident light of the same reinforcement, i_2 , and i_3 will have the wavelength dependency shown in drawing 4 in the photo detector of drawing 1 from which the rate of a current ratio shown in drawing 3 is obtained. In addition, the axis of ordinate in this drawing does not show a relative ratio, and does not show an absolute value. A dotted line is a relative spectral sensitivity curve (k) shown for these and a comparison, and it is drawn so that the point P chosen on current curvilinear i_2 may serve as a peak. Each current i_1 , i_2 , and i_3 can understand signs that it has a property greatly different, respectively from a relative spectral sensitivity curve (k).

[0019] Count of $i_3 - 0.67 \times i_1$ obtains the curve a of drawing 5 from each current characteristic of drawing 4. This curve a is a curve which increases to ∞ with the increment in wavelength, and just changes from negative between 500nm and 600nm. If the difference of current i_2 and the absolute value of this curve a is searched for and only a part for that positive part is taken out, the curve especially approximated to a relative spectral sensitivity curve (k) will be obtained. In drawing 5, $i_2 - |i_3 - 0.67 \times i_1|$ was calculated, only the curvilinear part from which the numeric value becomes zero or more was taken out, and it drew as a curve b. Having the wavelength selection nature which Curve b approximated with a sufficient precision to the relative spectral sensitivity curve (k) can understand from this drawing.

[0020] It cannot say that the property approximated to the relative spectral sensitivity curve is acquired by said count also about which photo detector of a configuration of having been shown in drawing 1, but this property follows the structure acquired according to the adopted bipolar process. That is, it is influenced by not only the depth of a plane of composition but various process conditions. However, the brightness output which has the wavelength selection nature of arbitration is obtained by performing suitable math processing to the current value of each obtained photodiode, taking the wavelength dependency of each current into consideration. A brightness detector with a high precision is obtained by making this wavelength selection nature in agreement with the wavelength selection nature of a relative spectral sensitivity curve.

[0021] Although the above-mentioned example showed an example which shall be different in each plane of composition according to the depth from a light-receiving front face in the wavelength selection nature to incident light, it replaces with this configuration and a mutually different configuration can also adopt the band gap of each plane of composition by changing the high impurity concentration in each epitaxial layer or a diffusion layer.

[0022]

[Effect of the Invention] Since selection of the wavelength selection nature to the light which carries out incidence to the light-receiving front face of the photo-electric-conversion section was enabled at arbitration according to the photo detector of this invention as explained above, the remarkable effectiveness whose manufacture of the brightness detector which can be made in agreement with human being's feeling with a sufficient precision was enabled is done so.

[0023] By arranging the semi-conductor layer which constitutes each plane of composition in the shape of a laminating, when it shall change the wavelength selection nature to the light which carries out incidence to a light-receiving front face with depth from a light-receiving front face, high impurity concentration of each semi-conductor layer can be chosen uniformly.

[0024] In differing the wavelength selection nature to the light which carries out incidence of the band gap of each plane of composition to a light-receiving front face as a mutually different thing, it bears a degree of freedom to arrangement of each diffusion layer.

[0025] When a photo detector is further equipped with an arithmetic circuit, the photodetector which has desired wavelength selection nature by the configuration of the arithmetic circuit to adopt is obtained.

[Translation done.]

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